SSD1315

Product Preview

128 x 64 Dot Matrix
OLED/PLED Segment/Common Driver with Controller

Appendix: IC Revision history of SSD1315 Specification

Version	Change Items	Effective Date
0.10	1st Release	31-Oct-16

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1 GENERAL DESCRIPTION

SSD1315 is a single-chip CMOS OLED/PLED driver with controller for organic/polymer light emitting diode dot-matrix graphic display system. It consists of 128 segments and 64 commons. This IC is designed for Common Cathode type OLED/PLED panel.

SSD1315 displays data directly from its internal 128 x 64 bits Graphic Display Data RAM (GDDRAM). Data/Commands are sent from general MCU through the hardware selectable I2C Interface, 6800-/8080-series compatible Parallel Interface or Serial Peripheral Interface.

The 256 steps contrast control and oscillator which embedded in SSD1315 reduces the number of external components. SSD1315 is suitable for portable applications requiring a compact size and high output brightness, such as set-top box, car audio, wearable electronics, etc.

2 FEATURES

- Resolution: 128 x 64 dot matrix panel
- Power supply
  - V_{DD} = 1.65V – 3.5V, ≤ V_{BAT} (for IC logic)
  - V_{BAT} = 3.0V – 4.5V (for charge bump regulator circuit)
  - V_{CC} = 7.5V – 16.5V (for Panel driving)
- Segment maximum source current: 240uA
- Common maximum sink current: 30mA
- Embedded 128 x 64 bit SRAM display buffer
- Pin selectable MCU Interfaces:
  - 8 bits 6800/8080-series parallel Interface
  - 3/4 wire Serial Peripheral Interface
  - I^2C Interface
- Screen saving continuous scrolling function in both horizontal and vertical direction
- Screen saving infinite content scrolling function
- Internal or external I_{REF} selection
- Internal charge pump regulator
- RAM write synchronization signal
- Programmable Frame Rate and Multiplexing Ratio
- Row Re-mapping and Column Re-mapping
- Power On Reset (POR)
- Dynamic Grayscale
- On-Chip Oscillator
- Chip layout for COG, COF
- Wide range of operating temperature: -40°C to 85°C

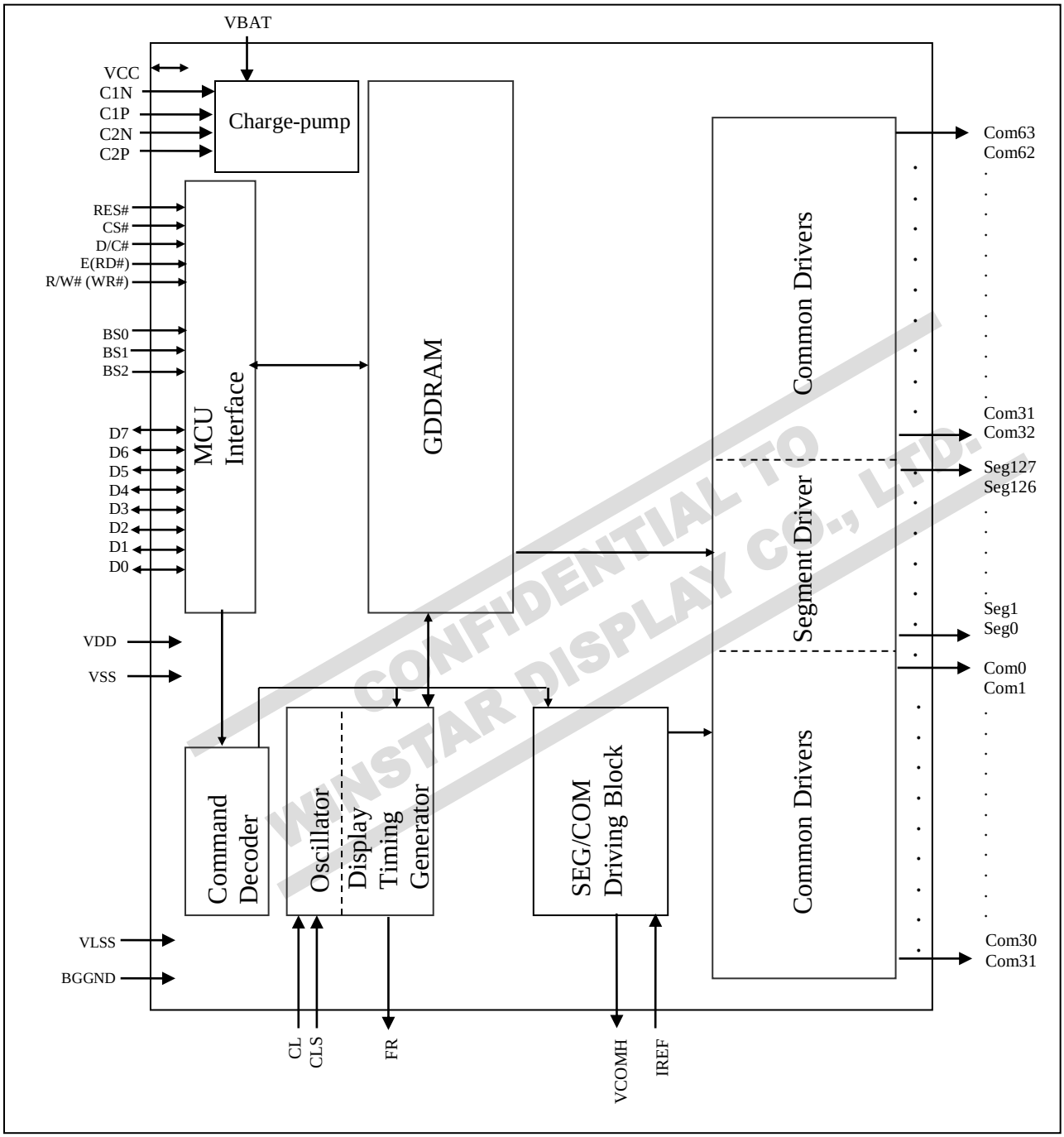
3 ORDERING INFORMATION

Table 3-1: Ordering Information

Ordering Part Number	SEG	COM	Package Form	Remark
SSD1315Z	128	64	COG	○ Min SEG pad pitch : 27um ○ Min COM pad pitch : 27um ○ Min I/O pad pitch : 30um ○ Die thickness: 250um ○ Bump height: nominal 9um

4 BLOCK DIAGRAM

Figure 4-1: SSD1315 Block Diagram



5 PIN DESCRIPTION

Key:

I = Input	NC = Not Connected
O = Output	Pull LOW = connect to Ground
I/O = Bi-directional (input/output)	Pull HIGH = connect to V_{DD}
P = Power pin	

Table 5-1: Pin Description

Pin Name	Type	Description
V_{DD}	P	Power supply pin for core logic operation.
V_{CC}	P	Power supply for panel driving voltage. This is also the most positive power voltage supply pin. When charge pump is enabled, a capacitor should be connected between this pin and V_{SS}.
V_{SS}	P	Ground pin. It must be connected to external ground.
V_{LSS}	P	This is an analog ground pin. It should be connected to V_{SS} externally.
V_{COMH}	O	COM signal deselected voltage level. A capacitor should be connected between this pin and V_{SS}.
V_{BAT}	P	Power supply for charge pump regulator circuit. Status / V_{BAT} / V_{DD} / V_{CC} Enable charge pump / Connect to external V_{BAT} source / Connect to external V_{DD} source / A capacitor should be connected between this pin and V_{SS} Disable charge pump / Keep float / Connect to external V_{DD} source / Connect to external V_{CC} source
BGGND	P	Reserved pin. It should be connected to V_{SS}.
C1P/C1N C2P/C2N	I	C1P/C1N – Pin for charge pump capacitor; Connect to each other with a capacitor. C2P/C2N – Pin for charge pump capacitor; Connect to each other with a capacitor.
LS	I	Reserved pin. It should be connected to V_{SS}.
BS[2:0]	I	MCU bus interface selection pins. Select appropriate logic setting as described in the following table. BS2, BS1 and BS0 are pin select. **Table 5-2: Bus Interface selection** BS[2:0] / Interface 000 / 4 line SPI 001 / 3 line SPI 010 / I^2C 110 / 8-bit 8080 parallel 100 / 8-bit 6800 parallel **Note** (1) 0 is connected to V_{SS} (2) 1 is connected to V_{DD}

Pin Name	Type	Description
I_{REF}	I	This is segment output current reference pin. When external I_{REF} is used, a resistor should be connected between this pin and V_{SS} to maintain the I_{REF} current at 30uA. Please refer to **Figure 6-15** for the details of resistor value. When internal I_{REF} is used, this pin should be kept NC.
FR	O	This pin outputs RAM write synchronization signal. Proper timing between MCU data writing and frame display timing can be achieved to prevent tearing effect. It should be kept NC if it is not used.
CL	I	This is external clock input pin. When internal clock is enabled (i.e. HIGH in CLS pin), this pin is not used and should be connected to V_{SS}. When internal clock is disabled (i.e. LOW in CLS pin), this pin is the external clock source input pin.
CLS	I	This is internal clock enable pin. When it is pulled HIGH (i.e. connect to V_{DD}), internal clock is enabled. When it is pulled LOW, the internal clock is disabled; an external clock source must be connected to the CL pin for normal operation.
RES#	I	This pin is reset signal input. When the pin is pulled LOW, initialization of the chip is executed. Keep this pin HIGH (i.e. connect to V_{DD}) during normal operation.
CS#	I	This pin is the chip select input connecting to the MCU. The chip is enabled for MCU communication only when CS# is pulled LOW (active LOW).
D/C#	I	This pin is Data/Command control pin connecting to the MCU. When the pin is pulled HIGH, the data at D[7:0] will be interpreted as data. When the pin is pulled LOW, the data at D[7:0] will be transferred to a command register. In I^2C mode, this pin acts as SA0 for slave address selection. When 3-wire serial interface is selected, this pin must be connected to V_{SS}. For detail relationship to MCU interface signals, refer to Timing Characteristics Diagrams **Figure 0-1** to **Figure 0-3**.
E (RD#)	I	This pin is MCU interface input. When 6800 interface mode is selected, this pin will be used as the Enable (E) signal. Read/write operation is initiated when this pin is pulled HIGH and the chip is selected. When 8080 interface mode is selected, this pin receives the Read (RD#) signal. Read operation is initiated when this pin is pulled LOW and the chip is selected. When serial or I^2C interface is selected, this pin must be connected to V_{SS}.
R/W#(WR#)	I	This is read / write control input pin connecting to the MCU interface. When interfacing to a 6800-series microprocessor, this pin will be used as Read/Write (R/W#) selection input. Read mode will be carried out when this pin is pulled HIGH (i.e. connect to V_{DD}) and write mode when LOW. When 8080 interface mode is selected, this pin will be the Write (WR#) input. Data write operation is initiated when this pin is pulled LOW and the chip is selected. When serial or I^2C interface is selected, this pin must be connected to V_{SS}.
D[7:0]	IO	These are 8-bit bi-directional data bus to be connected to the microprocessor's data bus. When serial interface mode is selected, D0 will be the serial clock input: SCLK; D1 will be the serial data input: SDIN. When I^2C mode is selected, D2, D1 should be tied together and serve as SDA_{out}, SDA_{in} in application and D0 is the serial clock input, SCL.

Pin Name	Type	Description
TR[12:0]	-	Reserved pin. It should be kept NC.
SEG0 ~ SEG127	O	These pins provide Segment switch signals to OLED panel. These pins are V_{SS} state when display is OFF.
COM0 ~ COM63	O	These pins provide Common switch signals to OLED panel. They are in high impedance state when display is OFF.
NC	-	This is dummy pin. It should be kept NC.

6 FUNCTIONAL BLOCK DESCRIPTIONS

6.1 MCU Interface Selection

SSD1315 MCU interface consist of 8 data pins and 5 control pins. The pin assignment at different interface mode is summarized in **Table 6-1**. Different MCU mode can be set by hardware selection on BS[2:0] pins (please refer to **Table 5-2** for BS[2:0] setting).

Table 6-1: MCU interface assignment under different bus interface mode

Pin Name / Bus Interface	Data/Command Interface								Control Signal				
	D7	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**E**	**R/W#**	**CS#**	**D/C#**	**RES#**
8-bit 8080	D[7:0]								RD#	WR#	CS#	D/C#	RES#
8-bit 6800	D[7:0]								E	R/W#	CS#	D/C#	RES#
3-wire SPI	Tie LOW						SDIN	SCLK	Tie LOW		CS#	Tie LOW	RES#
4-wire SPI	Tie LOW						SDIN	SCLK	Tie LOW		CS#	D/C#	RES#
I^2C	Tie LOW					SDA_{OUT}	SDA_{IN}	SCL	Tie LOW			SA0	RES#

6.1.1 MCU Parallel 6800-series Interface

The parallel interface consists of 8 bi-directional data pins (D[7:0]), R/W#, D/C#, E and CS#.

A LOW in R/W# indicates WRITE operation and HIGH in R/W# indicates READ operation.
A LOW in D/C# indicates COMMAND read/write and HIGH in D/C# indicates DATA read/write.
The E input serves as data latch signal while CS# is LOW. Data is latched at the falling edge of E signal.

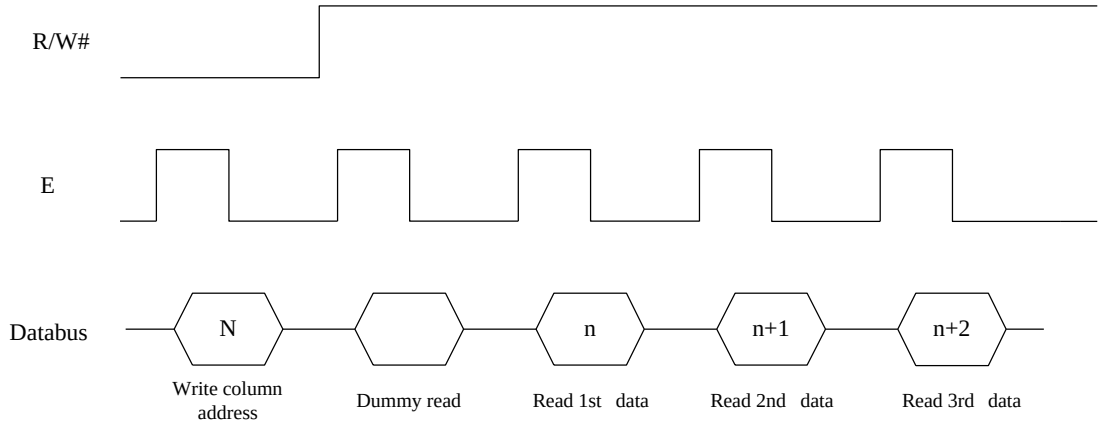
Table 6-2: Control pins of 6800 interface

Function	**E**	**R/W#**	**CS#**	**D/C#**
Write command	↓	L	L	L
Read status	↓	H	L	L
Write data	↓	L	L	H
Read data	↓	H	L	H

Note
(1) ↓ stands for falling edge of signal
H stands for HIGH in signal
L stands for LOW in signal

In order to match the operating frequency of display RAM with that of the microprocessor, some pipeline processing is internally performed which requires the insertion of a dummy read before the first actual display data read. This is shown in **Figure 6-1**.

Figure 6-1: Data read back procedure - insertion of dummy read



6.1.2 MCU Parallel 8080-series Interface

The parallel interface consists of 8 bi-directional data pins (D[7:0]), RD#, WR#, D/C# and CS#.

A LOW in D/C# indicates COMMAND read/write and HIGH in D/C# indicates DATA read/write.
A rising edge of RD# input serves as a data READ latch signal while CS# is kept LOW.
A rising edge of WR# input serves as a data/command WRITE latch signal while CS# is kept LOW.

Figure 6-2: Example of Write procedure in 8080 parallel interface mode

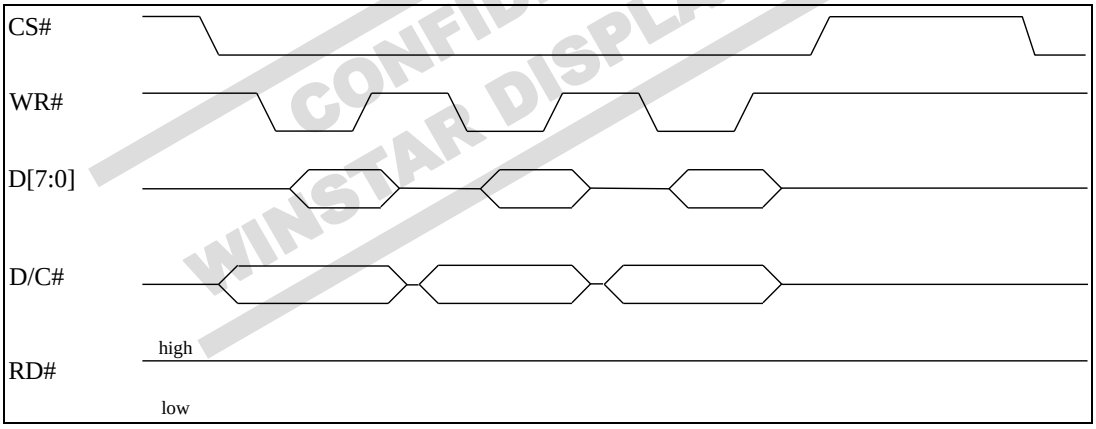


Figure 6-3: Example of Read procedure in 8080 parallel interface mode

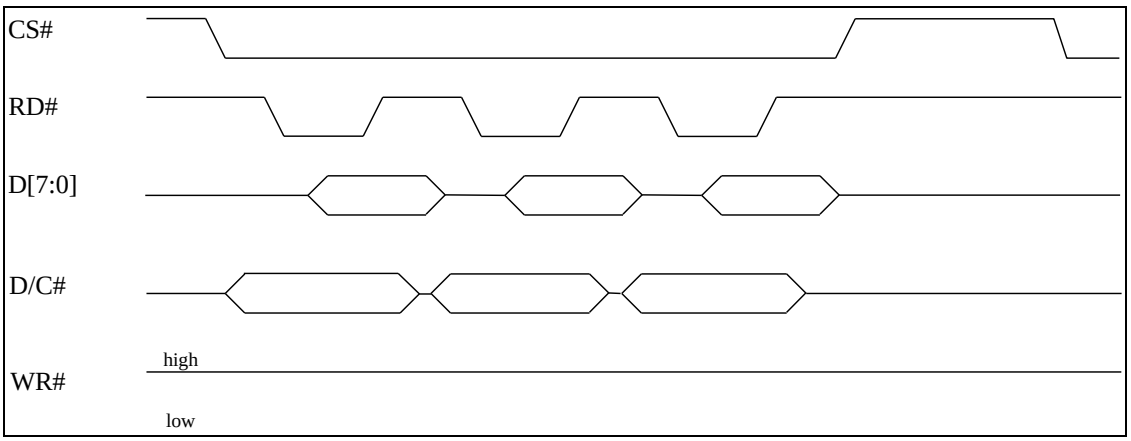


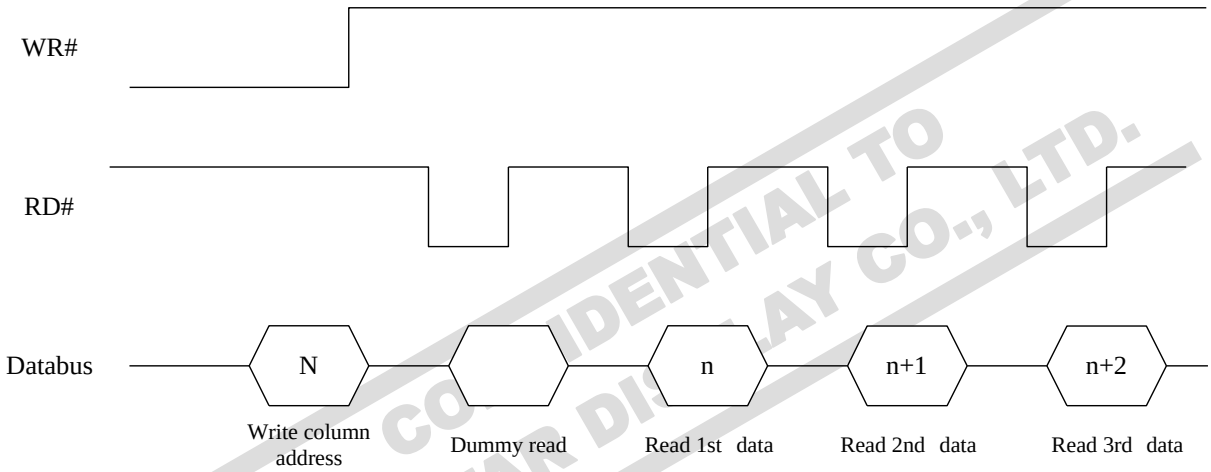
Table 6-3: Control pins of 8080 interface

Function	RD#	WR#	CS#	D/C#
Write command	H	↑	L	L
Read status	↑	H	L	L
Write data	H	↑	L	H
Read data	↑	H	L	H

Note
(1) ↑ stands for rising edge of signal
(2) H stands for HIGH in signal
(3) L stands for LOW in signal

In order to match the operating frequency of display RAM with that of the microprocessor, some pipeline processing is internally performed which requires the insertion of a dummy read before the first actual display data read. This is shown in **Figure 6-4**.

Figure 6-4: Display data read back procedure - insertion of dummy read



6.1.3 MCU Serial Interface (4-wire SPI)

The 4-wire serial interface consists of serial clock: SCLK, serial data: SDIN, D/C#, CS#. In 4-wire SPI mode, D0 acts as SCLK, D1 acts as SDIN. For the unused data pins from D2 to D7, E(RD#) and R/W#(WR#) can be connected to an external ground.

Table 6-4: Control pins of 4-wire Serial interface

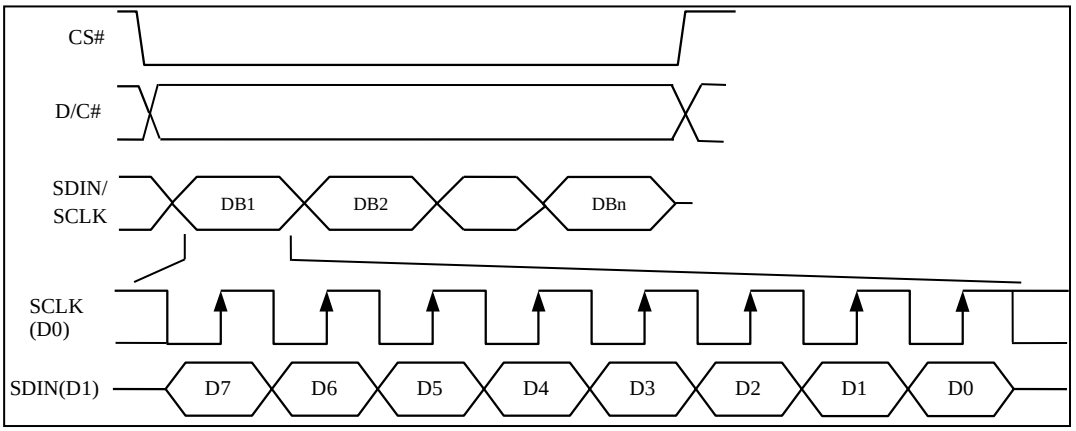
Function	E	R/W#	CS#	D/C#	D0
Write command	Tie LOW	Tie LOW	L	L	↑
Write data	Tie LOW	Tie LOW	L	H	↑

Note
(1) H stands for HIGH in signal
(2) L stands for LOW in signal
(3) ↑ stands for rising edge of signal

SDIN is shifted into an 8-bit shift register on every rising edge of SCLK in the order of D7, D6, ..., D0. D/C# is sampled on every eighth clock and D/C# should be kept stable throughout eight clock period. The data byte in the shift register is written to the Graphic Display Data RAM (GDDRAM) or command register in the same clock.

Under serial mode, only write operations are allowed.

Figure 6-5: Write procedure in 4-wire Serial interface mode



6.1.4 MCU Serial Interface (3-wire SPI)

The 3-wire serial interface consists of serial clock SCLK, serial data SDIN and CS#.
In 3-wire SPI mode, D0 acts as SCLK, D1 acts as SDIN. For the unused data pins from D2 to D7, R/W# (WR#), E(RD#) and D/C# can be connected to an external ground.

The operation is similar to 4-wire serial interface while D/C# pin is not used. There are altogether 9-bits will be shifted into the shift register on every ninth clock in sequence: D/C# bit, D7 to D0 bit. The D/C# bit (first bit of the sequential data) will determine the following data byte in the shift register is written to the Display Data RAM (D/C# bit = 1) or the command register (D/C# bit = 0).

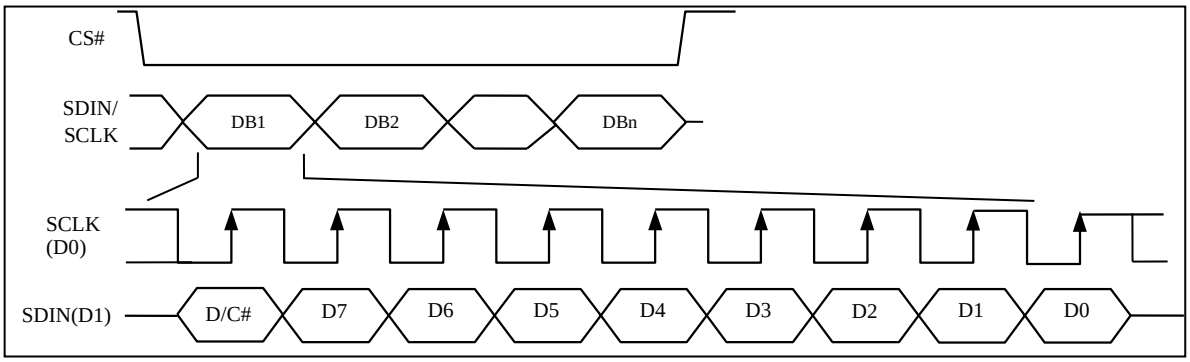
Under serial mode, only write operations are allowed.

Table 6-5: Control pins of 3-wire Serial interface

Function	E(RD#)	R/W#(WR#)	CS#	D/C#	D0
Write command	Tie LOW	Tie LOW	L	Tie LOW	↑
Write data	Tie LOW	Tie LOW	L	Tie LOW	↑

Note
(1) L stands for LOW in signal
(2) ↑ stands for rising edge of signal

Figure 6-6: Write procedure in 3-wire Serial interface mode



6.1.5 MCU I2C Interface

The I^2C communication interface consists of slave address bit SA0, I^2C-bus data signal SDA (SDA_{OUT}/D_2 for output and SDA_{IN}/D_1 for input) and I^2C-bus clock signal SCL (D_0). Both the data and clock signals must be connected to pull-up resistors. RES# is used for the initialization of device.

a) Slave address bit (SA0)
SSD1315 has to recognize the slave address before transmitting or receiving any information by the I^2C-bus. The device will respond to the slave address following by the slave address bit ("SA0" bit) and the read/write select bit ("R/W#" bit) with the following byte format,

b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
0	1	1	1	1	0	SA0	R/W#

"SA0" bit provides an extension bit for the slave address. Either "0111100" or "0111101", can be selected as the slave address of SSD1315. D/C# pin acts as SA0 for slave address selection.
"R/W#" bit is used to determine the operation mode of the I^2C-bus interface. R/W# = 1, it is in read mode. R/W# = 0, it is in write mode.

b) I^2C-bus data signal (SDA)
SDA acts as a communication channel between the transmitter and the receiver. The data and the acknowledgement are sent through the SDA.

It should be noticed that the ITO track resistance and the pulled-up resistance at "SDA" pin becomes a voltage potential divider. As a result, the acknowledgement would not be possible to attain a valid logic 0 level in "SDA".

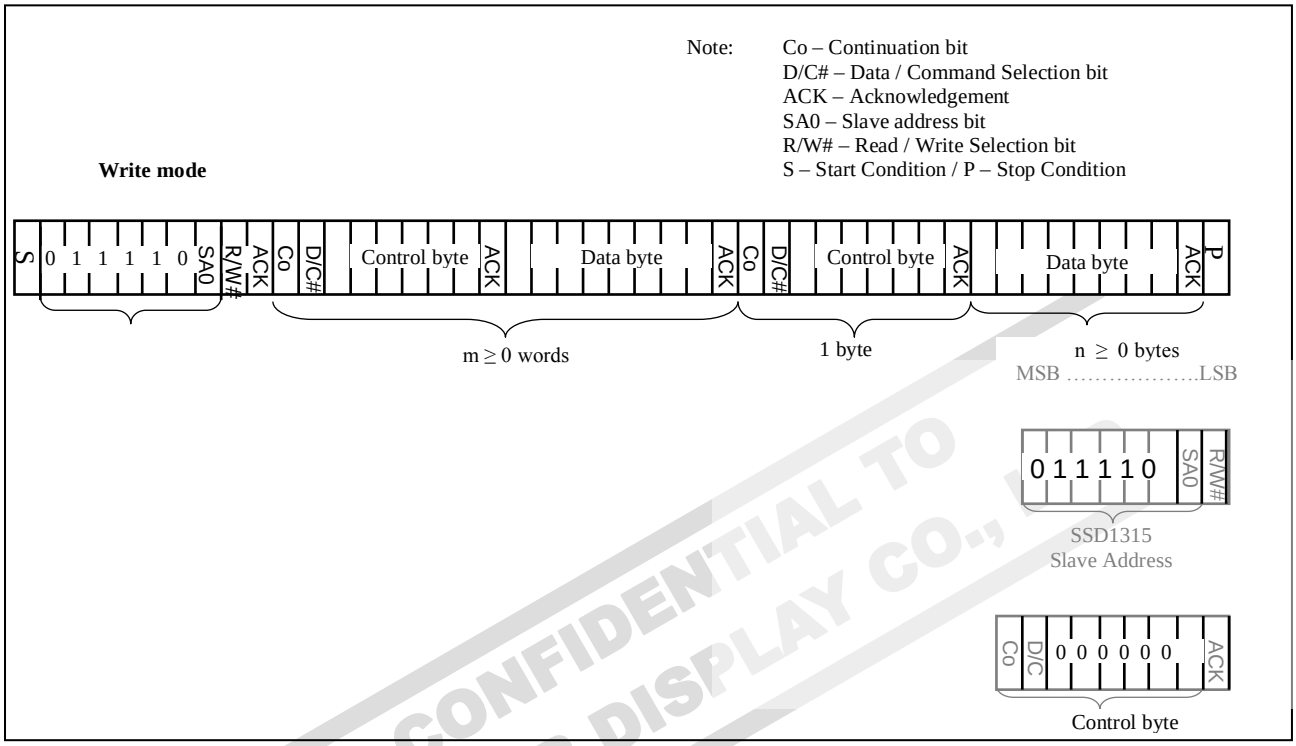
"SDA_{IN}" and "SDA_{OUT}" are tied together and serve as SDA. The "SDA_{IN}" pin must be connected to act as SDA. The "SDA_{OUT}" pin may be disconnected. When "SDA_{OUT}" pin is disconnected, the acknowledgement signal will be ignored in the I^2C-bus.

c) I^2C-bus clock signal (SCL)
The transmission of information in the I^2C-bus is following a clock signal, SCL. Each transmission of data bit is taken place during a single clock period of SCL.

6.1.5.1 I²C-bus Write Data

The I²C-bus interface gives access to write data and command into the device. Please refer to for the write mode of I²C-bus in chronological order.

Figure 6-7: I²C-bus data format



6.1.5.2 Write mode for I2C

1) The master device initiates the data communication by a start condition. The definition of the start condition is shown in **Figure 6-8**. The start condition is established by pulling the SDA from HIGH to LOW while the SCL stays HIGH.
2) The slave address is following the start condition for recognition use. For the SSD1315, the slave address is either "b0111100" or "b0111101" by changing the SA0 to LOW or HIGH (D/C pin acts as SA0).
3) The write mode is established by setting the R/W# bit to logic "0".
4) An acknowledgement signal will be generated after receiving one byte of data, including the slave address and the R/W# bit. Please refer to the **Figure 6-9** for the graphical representation of the acknowledge signal. The acknowledge bit is defined as the SDA line is pulled down during the HIGH period of the acknowledgement related clock pulse.
5) After the transmission of the slave address, either the control byte or the data byte may be sent across the SDA. A control byte mainly consists of Co and D/C# bits following by six "0" 's.
    a. If the Co bit is set as logic "0", the transmission of the following information will contain data bytes only.
    b. The D/C# bit determines the next data byte is acted as a command or a data. If the D/C# bit is set to logic "0", it defines the following data byte as a command. If the D/C# bit is set to logic "1", it defines the following data byte as a data which will be stored at the GDDRAM. The GDDRAM column address pointer will be increased by one automatically after each data write.
6) Acknowledge bit will be generated after receiving each control byte or data byte.
7) The write mode will be finished when a stop condition is applied. The stop condition is also defined in **Figure 6-8**. The stop condition is established by pulling the "SDA in" from LOW to HIGH while the "SCL" stays HIGH.

Figure 6-8: Definition of the Start and Stop Condition

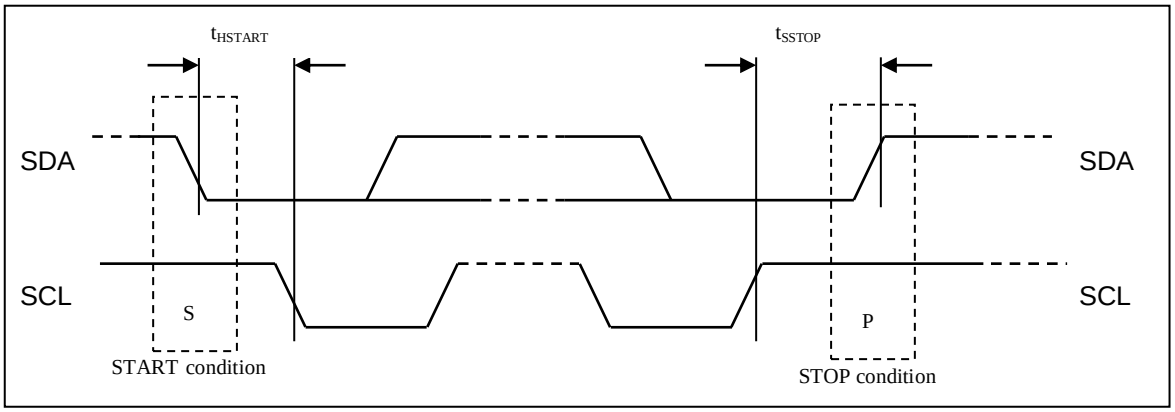
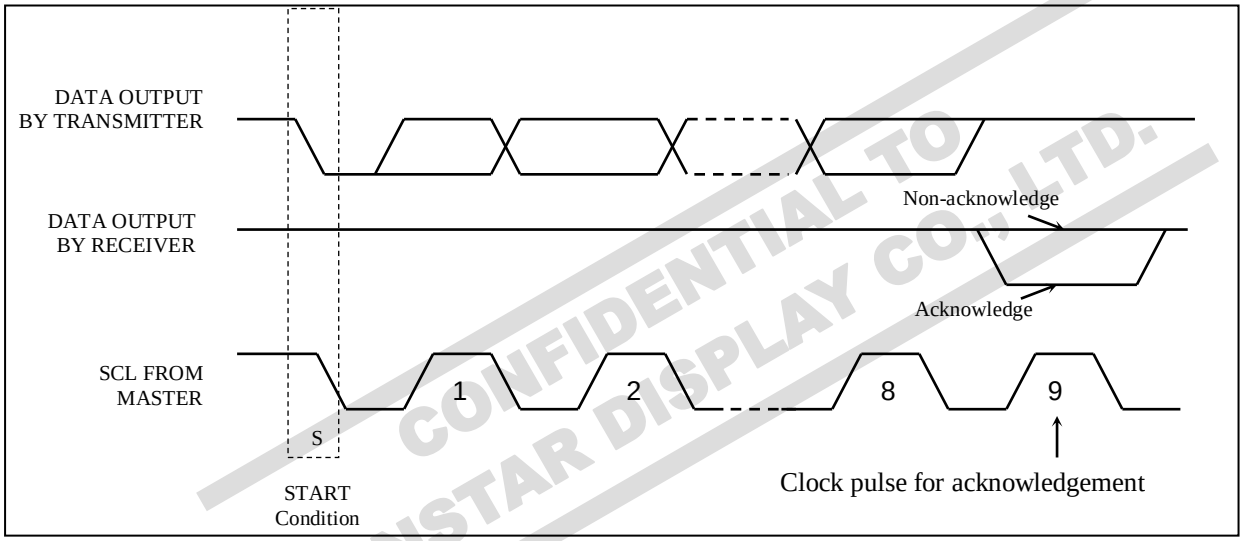


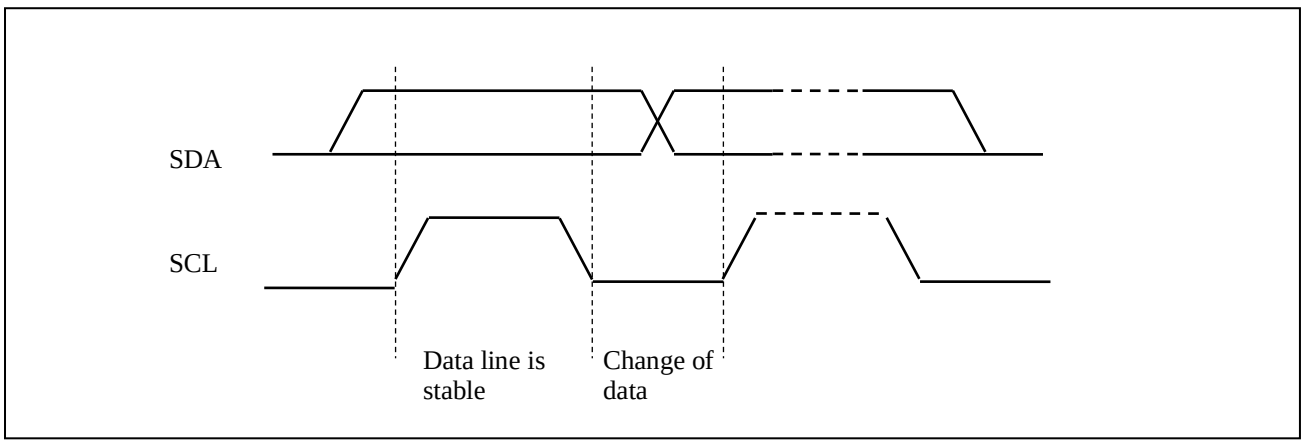
Figure 6-9: Definition of the acknowledgement condition



Please be noted that the transmission of the data bit has some limitations.

1. The data bit, which is transmitted during each SCL pulse, must keep at a stable state within the "HIGH" period of the clock pulse. Please refer to the **Figure 6-10** for graphical representations. Except in start or stop conditions, the data line can be switched only when the SCL is LOW.
2. Both the data line (SDA) and the clock line (SCL) should be pulled up by external resistors.

Figure 6-10: Definition of the data transfer condition



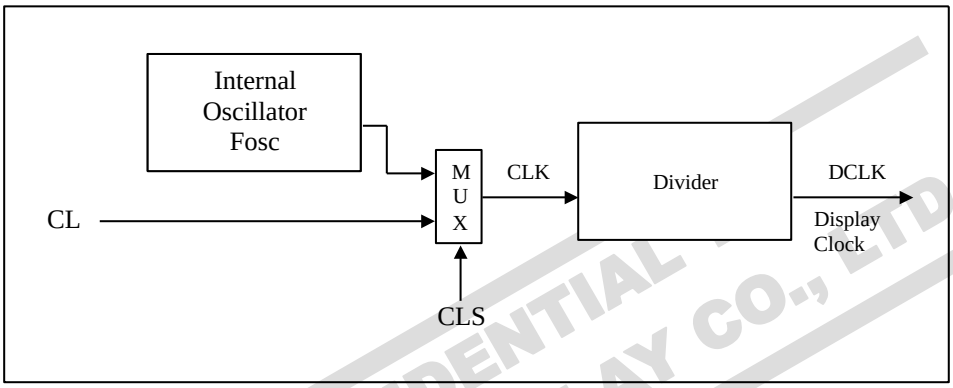
6.2 Command Decoder

This module determines whether the input data is interpreted as data or command. Data is interpreted based upon the input of the D/C# pin.

If D/C# pin is HIGH, D[7:0] is interpreted as display data written to Graphic Display Data RAM (GDDRAM). If it is LOW, the input at D[7:0] is interpreted as a command. Then data input will be decoded and written to the corresponding command register.

6.3 Oscillator Circuit and Display Time Generator

Figure 6-11: Oscillator Circuit and Display Time Generator



This module is an on-chip LOW power RC oscillator circuitry. The operation clock (CLK) can be generated either from internal oscillator or external source CL pin. This selection is done by CLS pin. If CLS pin is pulled HIGH, internal oscillator is chosen and CL should be connected to V_{SS}. Pulling CLS pin LOW disables internal oscillator and external clock must be connected to CL pins for proper operation. When the internal oscillator is selected, its output frequency F_{OSC} can be changed by command D5h A[7:4].

The display clock (DCLK) for the Display Timing Generator is derived from CLK. The division factor "D" can be programmed from 1 to 16 by command D5h

$$DCLK = F_{OSC} / D$$

The frame frequency of display is determined by the following formula.

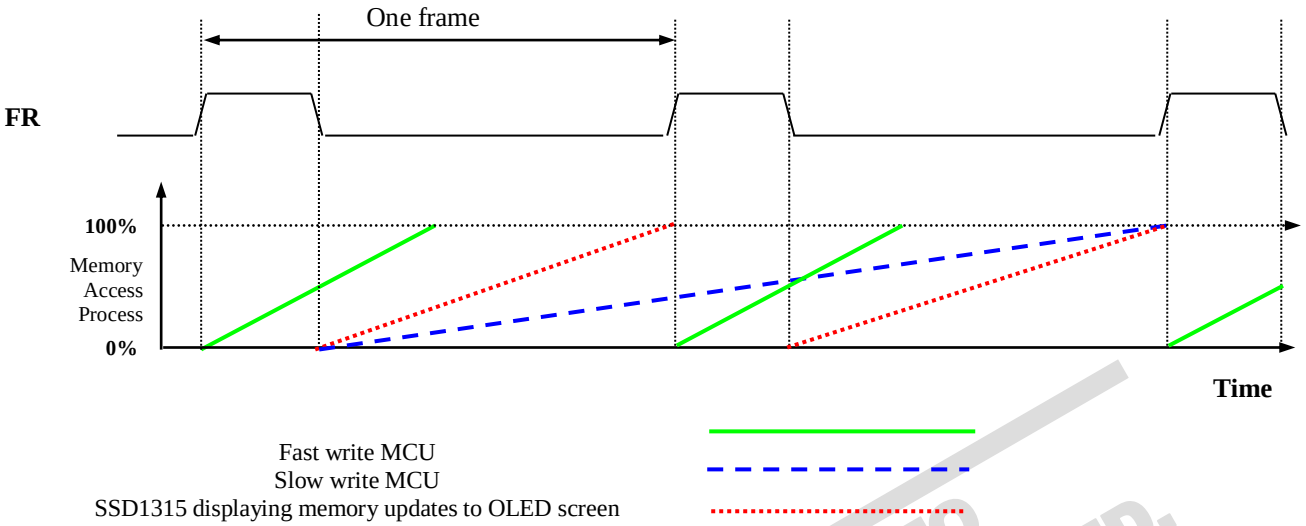
$$F_{FRM} = \frac{F_{osc}}{D \times K \times No.\,of\ Mux}$$

where

- D stands for clock divide ratio. It is set by command D5h A[3:0]. The divide ratio has the range from 1 to 16.
- K is the number of display clocks per row. The value is derived by
  K = Phase 1 period + Phase 2 period + K_0 = 2 + 2 + 99 = 103 at power on reset (i.e. K_0 = 99)
  Please refer to **Section 6.6** for the details of the "Phase".
- Number of multiplex ratio is set by command A8h. The power on reset value is 63 (i.e. 64MUX).
- F_{OSC} is the oscillator frequency. It can be changed by command D5h A[7:4]. The higher the register setting results in higher frequency.

6.4 FR Synchronization

FR synchronization signal can be used to prevent tearing effect.



The starting time to write a new image to OLED driver is depended on the MCU writing speed. If MCU can finish writing a frame image within one frame period, it is classified as fast write MCU. For MCU needs longer writing time to complete (more than one frame but within two frames), it is a slow write one.

For fast write MCU: MCU should start to write new frame of ram data just after rising edge of FR pulse and should be finished well before the rising edge of the next FR pulse.

For slow write MCU: MCU should start to write new frame ram data after the falling edge of the 1st FR pulse and must be finished before the rising edge of the 3rd FR pulse.

6.5 Reset Circuit

When RES# input is LOW, the chip is initialized with the following status:

1. Display is OFF
2. 128 x 64 Display Mode
3. Normal segment and display data column address and row address mapping (SEG0 mapped to address 00h and COM0 mapped to address 00h)
4. Shift register data clear in serial interface
5. Display start line is set at display RAM address 0
6. Column address counter is set at 0
7. Normal scan direction of the COM outputs
8. Contrast control register is set at 7Fh
9. Normal display mode (Equivalent to A4h command)

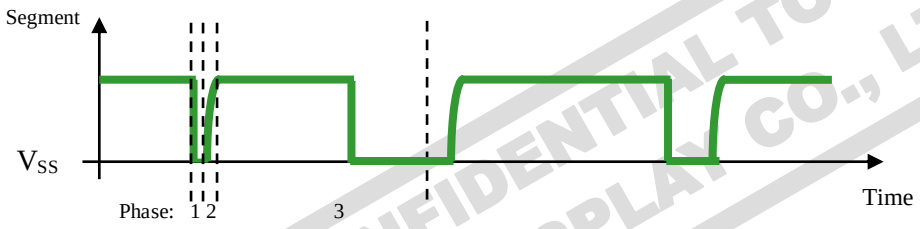
6.6 Segment Drivers / Common Drivers

Segment drivers deliver 128 current sources to drive the OLED panel. The driving current can be adjusted by altering the registers of the contrast setting command (81h). Common drivers generate voltage-scanning pulses.

The segment driving waveform is divided into three phases:

1. In phase 1, the OLED pixel charges of previous image are discharged in order to prepare for next image content display.
2. In phase 2, the OLED pixel is driven to the targeted voltage. The pixel is driven to attain the corresponding voltage level from VSS. The period of phase 2 can be programmed in length from 1 to 16 DCLKs. If the capacitance value of the pixel of OLED panel is larger, a longer period is required to charge up the capacitor to reach the desired voltage.
3. In phase 3, the OLED driver switches to use current source to drive the OLED pixels and this is the current drive stage.

Figure 6-12: Segment Output Waveform in three phases



After finishing phase 3, the driver IC will go back to phase 1 to display the next row image data. This three-step cycle is run continuously to refresh image display on OLED panel.

In phase 3, if the length of current drive pulse width is set to 99, after finishing 99 DCLKs in current drive phase, the driver IC will go back to phase 1 for next row display.

6.7 Graphic Display Data RAM (GDDRAM)

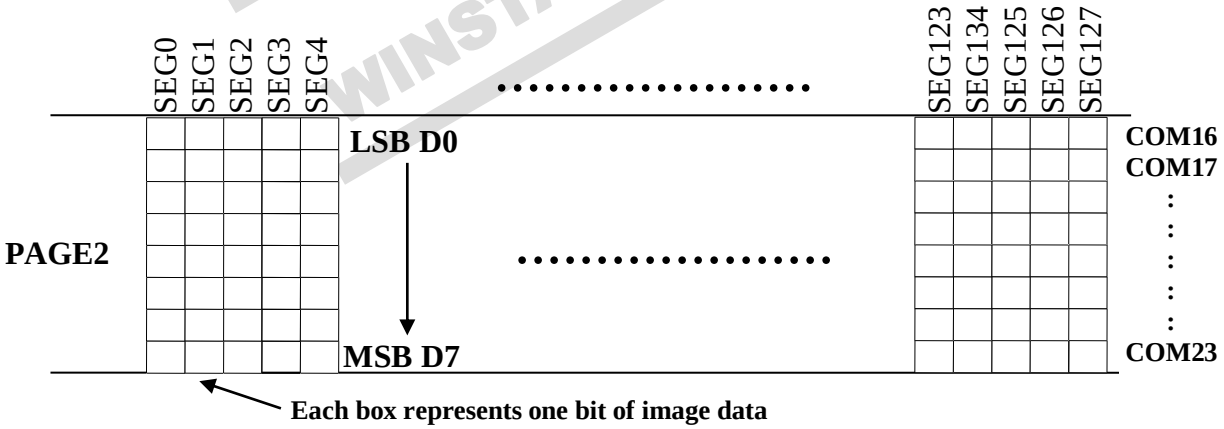
The GDDRAM is a bit mapped static RAM holding the bit pattern to be displayed. The size of the RAM is 128 x 64 bits and the RAM is divided into eight pages, from PAGE0 to PAGE7, which are used for monochrome 128x64 dot matrix display, as shown in **Figure 6-13**.

Figure 6-13: GDDRAM pages structure

		Row re-mapping
PAGE0 (COM0-COM7)	Page 0	PAGE0 (COM 63-COM56)
PAGE1 (COM8-COM15)	Page 1	PAGE1 (COM 55-COM48)
PAGE2 (COM16-COM23)	Page 2	PAGE2 (COM47-COM40)
PAGE3 (COM24-COM31)	Page 3	PAGE3 (COM39-COM32)
PAGE4 (COM32-COM39)	Page 4	PAGE4 (COM31-COM24)
PAGE5 (COM40-COM47)	Page 5	PAGE5 (COM23-COM16)
PAGE6 (COM48–COM55)	Page 6	PAGE6 (COM15-COM8)
PAGE7 (COM56-COM63)	Page 7	PAGE7 (COM 7-COM0)
	SEG0 ----------SEG127	
Column re-mapping	SEG127 ----------SEG0	

When one data byte is written into GDDRAM, all the rows image data of the same page of the current column are filled (i.e. the whole column (8 bits) pointed by the column address pointer is filled.). Data bit D0 is written into the top row, while data bit D7 is written into bottom row as shown in **Figure 6-14**.

Figure 6-14: Enlargement of GDDRAM (No row re-mapping and column-remapping)



For mechanical flexibility, re-mapping on both Segment and Common outputs can be selected by software as shown in **Figure 6-13**.

For vertical shifting of the display, an internal register storing the display start line can be set to control the portion of the RAM data to be mapped to the display (command D3h).

6.8 SEG/COM Driving Block

This block is used to derive the incoming power sources into the different levels of internal use voltage and current.

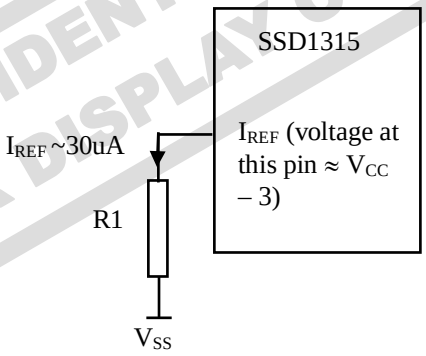
- V_{CC} is the most positive voltage supply.
- V_{COMH} is the Common deselected level. It is internally regulated.
- V_{LSS} is the ground path of the analog and panel current.
- I_{REF} is a reference current source for segment current drivers I_{SEG}. The relationship between reference current and segment current of a color is:

  I_{SEG} = (Contrast / 32) x I_{REF}

  in which the contrast (1~255) is set by Set Contrast command 81h

When external I_{REF} is used, the magnitude of I_{REF} is controlled by the value of resistor, which is connected between I_{REF} pin and V_{SS} as shown in **Figure 6-15**. It is recommended to set I_{REF} to 30±2uA so as to achieve I_{SEG} = 240uA at maximum contrast 255.

Figure 6-15: I_{REF} Current Setting by Resistor Value



Since the voltage at I_{REF} pin is V_{CC} – 3V, the value of resistor R1 can be found as below:

For I_{REF} = 30uA, V_{CC} =12V:

R1 = (Voltage at I_{REF} – V_{SS}) / I_{REF}
≈ (12 – 3) / 30uA
= 300KΩ

When internal I_{REF} is used, the I_{REF} pin should be kept NC and the I_{SEG} can be set as either 150uA or 240uA (max) by software command ADh setting. The selection of external or internal I_{REF} is also controlled by command ADh. For details, please refer to SSD1315 Command Table.

6.9 Power ON and OFF Sequence

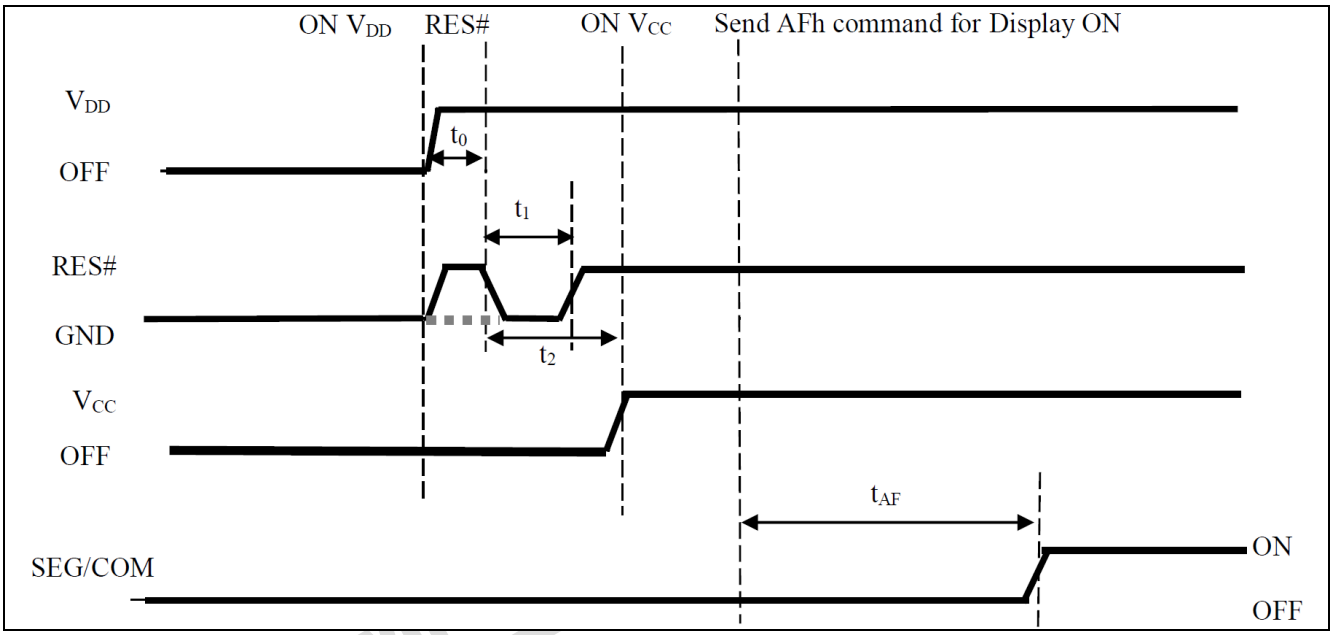
The following figures illustrate the recommended power ON and power OFF sequence of SSD1315.

6.9.1 Power ON and OFF sequence with External V_{CC}

Power ON sequence:

1. Power ON V_{DD}
2. After V_{DD} become stable, wait at least 20ms (t_0), set RES# pin LOW (logic low) for at least 3us (t_1) [4] and then HIGH (logic high).
3. After set RES# pin LOW (logic low), wait for at least 3us (t_2). Then Power ON V_{CC}.[1]
4. After V_{CC} become stable, send command AFh for display ON. SEG/COM will be ON after 100ms (t_{AF}).

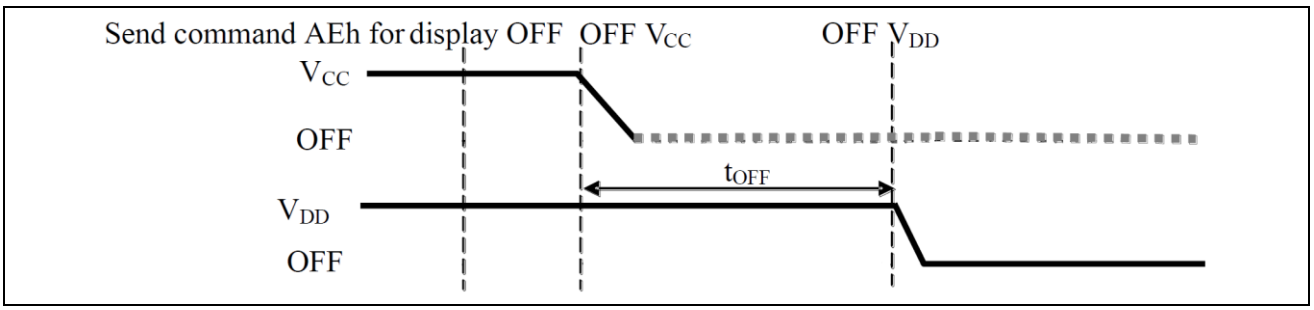
Figure 6-16: The Power ON Sequence



Power OFF sequence:

1. Send command AEh for display OFF.
2. Power OFF V_{CC}.[1], [2]
3. Power OFF V_{DD} after t_{OFF}. [4] (where Minimum t_{OFF}=0ms, typical t_{OFF}=100ms)

Figure 6-17: The Power OFF Sequence



Note:

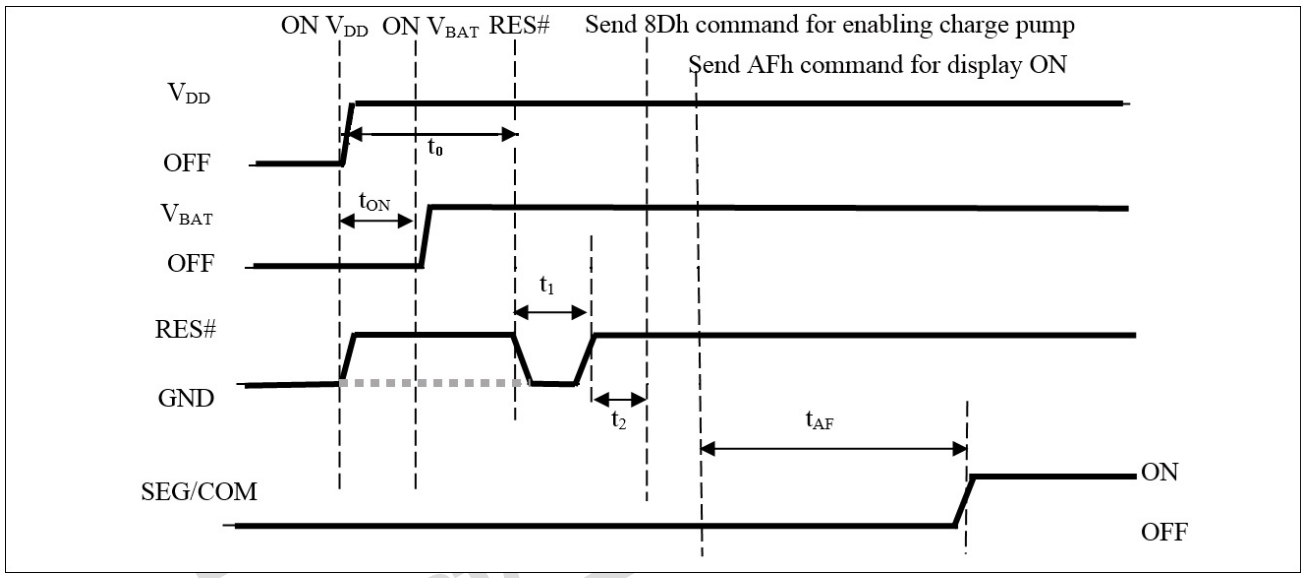
(1) V_{CC} should be kept float (i.e. disable) when it is OFF.
(2) Power Pins (V_{DD}, V_{CC}) can never be pulled to ground under any circumstance.
(3) The register values are reset after t_1.
(4) V_{DD} should not be Power OFF before V_{CC} Power OFF.

6.9.2 Power ON and OFF sequence with Charge Pump Application

Power ON sequence:

1. Power ON V_{DD}
2. Wait for t_{ON}. Power ON V_{BAT}. (where Minimum t_{ON} = 0ms)
3. After V_{DD} become stable, wait at least 20ms (t_0), set RES# pin LOW (logic low) for at least 3us (t_1) [3] and then HIGH (logic high).
4. After set RES# pin LOW (logic low), wait for at least 3us (t_2). Then input commands with below sequence:
    a. 8Dh for enabling internal charge pump
    b. AFh for display ON
5. SEG/COM will be ON after 100ms (t_{AF}).

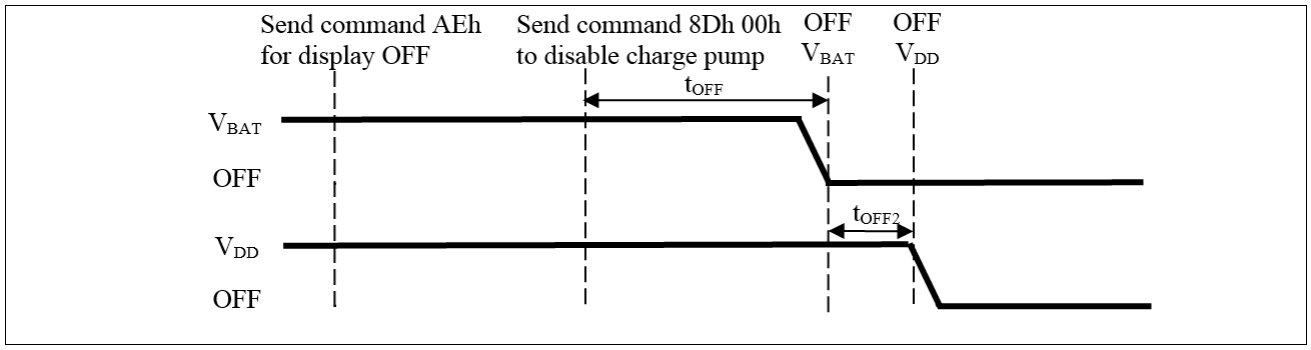
Figure 6-18: The Power ON sequence with Charge Pump Application



Power OFF sequence:

1. Send command AEh for display OFF
2. Send command 8Dh 10h to disable charge pump
3. Power OFF V_{BAT} after t_{OFF}. [1], [2] (Typical t_{OFF} =100ms)
4. Power OFF V_{DD} after t_{OFF2}. (where Minimum t_{OFF2} = 0ms [4] , Typical t_{OFF2}=5ms)

Figure 6-19: The Power OFF sequence with Charge Pump Application



Note:

[1] V_{BAT} should be kept float (i.e. disable) when it is OFF.
[2] Power Pins (V_{BAT}) can never be pulled to ground under any circumstance.
[3] The register values are reset after t_1.
[4] V_{DD} should not be Power OFF before V_{BAT} Power OFF.

6.10 Charge Pump Regulator

The internal regulator circuit in SSD1315 accompanying only 2 external capacitors can generate a maximum of 9.0V voltage supply, V_{CC} and a maximum output loading of 12mA from a low voltage supply input, V_{BAT}. In SSD1315, there are 3 charge pump output V_{CC} setting, 7.5V, 8.5V and 9V, which can be selected by software command 8Dh setting. The V_{CC} is the voltage supply to the OLED driver block. This regulator can be turned ON/OFF by software command 8Dh setting. For details, please refer to SSD1315 Command Table.

7 MAXIMUM RATINGS

Table 7-1: Maximum Ratings

(Voltage Reference to V_{SS})

Symbol	Parameter	Value	Unit
V_{DD}	Supply Voltage	-0.3 to +4	V
V_{BAT}		-0.3 to +6	V
V_{CC}		0 to 18	V
V_{SEG}	SEG output voltage	0 to V_{CC}	V
V_{COM}	COM output voltage	0 to 0.9*V_{CC}	V
V_{in}	Input voltage	V_{SS}-0.3 to V_{DD}+0.3	V
T_A	Operating Temperature	-40 to +85	℃
T_{stg}	Storage Temperature Range	-65 to +150	℃

*Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the Electrical Characteristics tables or Pin Description.

*This device may be light sensitive. Caution should be taken to avoid exposure of this device to any light source during normal operation. This device is not radiation protected.

8 DC CHARACTERISTICS

Condition (Unless otherwise specified):

Voltage referenced to V_{SS}

V_{DD} = 1.65V to 3.5V

T_A = 25°C

Table 8-1: DC Characteristics

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
V_{CC}	Operating Voltage	-	7.5	-	16.5	V
V_{DD}	Logic Supply Voltage	-	1.65	-	3.5	V
V_{BAT}	Charge Pump Regulator Supply Voltage	-	3.0	-	4.5	V
Charge Pump V_{CC}	Charge Pump Output Voltage	7.5V mode	7	7.5	-	V
		8.5V mode	8	8.5	-	
		9V mode	8.5	9	-	
V_{OH}	High Logic Output Level	I_{OUT} = 100uA, 3.3MHz	0.9 x V_{DD}	-	-	V
V_{OL}	Low Logic Output Level	I_{OUT} = 100uA, 3.3MHz	-	-	0.1 x V_{DD}	V
V_{IH}	High Logic Input Level	-	0.8 x V_{DD}	-	-	V
V_{IL}	Low Logic Input Level	-	-	-	0.2 x V_{DD}	V
$I_{CC, SLEEP}$	I_{CC}, Sleep mode Current	V_{DD} = 1.65V~3.5V, V_{CC} = 7.5V~16.5V Display OFF, No panel attached	-	-	10	uA
$I_{DD, SLEEP}$	I_{DD}, Sleep mode Current	V_{DD} = 1.65V~3.5V, V_{CC} = 7.5V~16.5V Display OFF, No panel attached	-	-	10	uA
$I_{BAT, SLEEP}$	I_{BAT}, Sleep mode Current	V_{DD} = 1.65V~3.5V, V_{BAT} = 2.4V~4.5V Display OFF, No panel attached	-	-	10	uA
I_{CC}	V_{CC} Supply Current V_{DD} = 2.8V, V_{CC} = 12V, I_{REF} = 30uA No loading, Display ON, All ON	Contrast = FFh	-	625	1000	uA
I_{DD}	V_{DD} Supply Current V_{DD} = 2.8V, V_{CC} = 12V, I_{REF} = 30uA No loading, Display ON, All ON		-	160	220	uA
I_{SEG}	Segment Output Current V_{DD}=2.8V, V_{CC}=12V, I_{REF}=30uA, Display ON.	Contrast=FFh	-	240	-	uA
		Contrast=AFh	-	165	-	
		Contrast=3Fh	-	60	-	
I_{SEG}	Segment Output Current V_{DD}=2.8V, V_{CC}=12V, I_{REF}=19uA, Display ON.	Contrast=FFh	-	150	-	uA
		Contrast=AFh	-	104	-	
		Contrast=3Fh	-	38	-	
Dev	Segment output current uniformity	Dev = (I_{SEG} – I_{MID})/I_{MID} I_{MID} = (I_{MAX} + I_{MIN})/2 I_{SEG}[0:131] = Segment current at contrast = FFh	-3	-	+3	%
Adj. Dev	Adjacent pin output current uniformity (contrast = FF)	Adj Dev = (I[n]-I[n+1]) / (I[n]+I[n+1])	-2	-	+2	%

AC CHARACTERISTICS

Conditions:

Voltage referenced to V_{SS}
V_{DD}=1.65 to 3.5V
T_A = 25°C

Table 0-1: AC Characteristics

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
F_{OSC} (1)	Oscillation Frequency of Display Timing Generator	V_{DD} = 2.8V	620	688	756	kHz
F_{FRM}	Frame Frequency	128x64 Graphic Display Mode, Display ON, Internal Oscillator Enabled	-	F_{OSC} x 1/(DxKx64)(2)	-	Hz
RES#	Reset low pulse width		3	-	-	us

Note

(1) F_{OSC} stands for the frequency value of the internal oscillator and the value is measured when command D5h A[7:4] is in default value.

(2) D: divide ratio (default value = 1)
K: number of display clocks per row period (default value = 103)

Table 0-2: 6800-Series MCU Parallel Interface Timing Characteristics

(V_{DD} - V_{SS} = 1.65V to 3.5V, T_A = 25℃)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	300	-	-	ns
t_{AS}	Address Setup Time	5	-	-	ns
t_{AH}	Address Hold Time	0	-	-	ns
t_{DSW}	Write Data Setup Time	40	-	-	ns
t_{DHW}	Write Data Hold Time	7	-	-	ns
t_{DHR}	Read Data Hold Time	20	-	-	ns
t_{OH}	Output Disable Time	-	-	70	ns
t_{ACC}	Access Time	-	-	140	ns
PW_{CSL}	Chip Select Low Pulse Width (read) Chip Select Low Pulse Width (write)	120 60	-	-	ns
PW_{CSH}	Chip Select High Pulse Width (read) Chip Select High Pulse Width (write)	60 60	-	-	ns
t_R	Rise Time	-	-	40	ns
t_F	Fall Time	-	-	40	ns

Figure 0-1: 6800-series MCU parallel interface characteristics

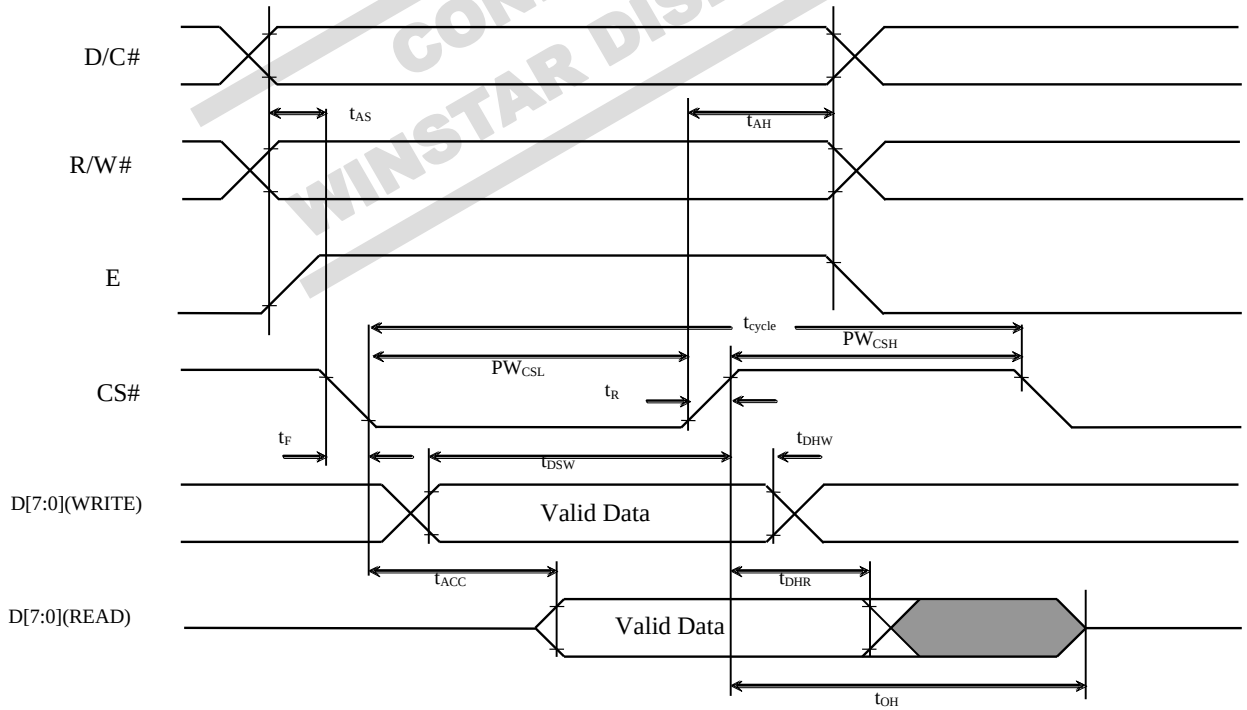
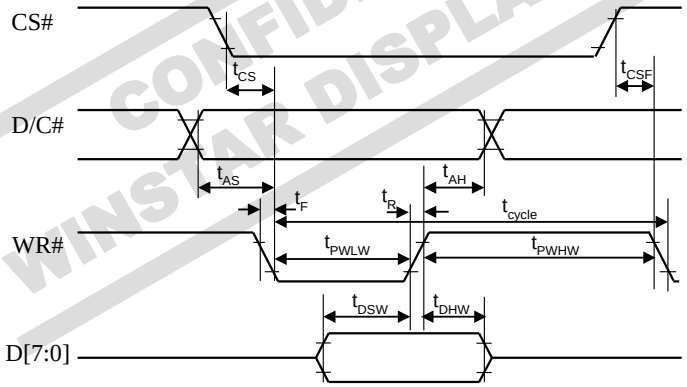


Table 0-3: 8080-Series MCU Parallel Interface Timing Characteristics

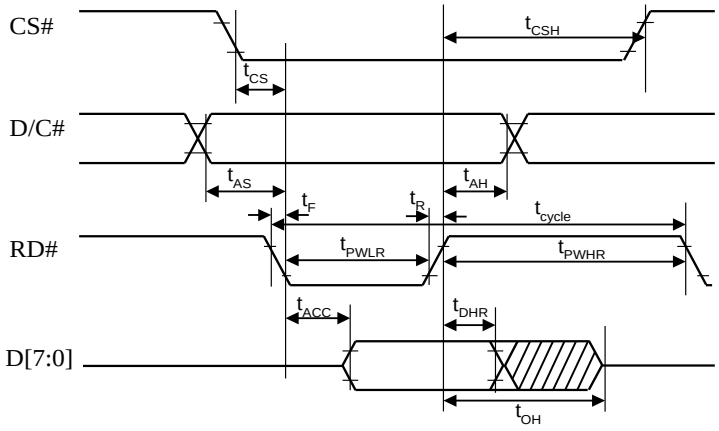
(V_{DD} - V_{SS} = 1.65V ~3.5V, T_A = 25℃)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	300	-	-	ns
t_{AS}	Address Setup Time	10	-	-	ns
t_{AH}	Address Hold Time	0	-	-	ns
t_{DSW}	Write Data Setup Time	40	-	-	ns
t_{DHW}	Write Data Hold Time	7	-	-	ns
t_{DHR}	Read Data Hold Time	20	-	-	ns
t_{OH}	Output Disable Time	-	-	70	ns
t_{ACC}	Access Time	-	-	140	ns
t_{PWLR}	Read Low Time	120	-	-	ns
t_{PWLW}	Write Low Time	60	-	-	ns
t_{PWHR}	Read High Time	60	-	-	ns
t_{PWHW}	Write High Time	60	-	-	ns
t_R	Rise Time	-	-	40	ns
t_F	Fall Time	-	-	40	ns
t_{CS}	Chip select setup time	0	-	-	ns
t_{CSH}	Chip select hold time to read signal	0	-	-	ns
t_{CSF}	Chip select hold time	20	-	-	ns

Figure 0-2: 8080-series parallel interface characteristics



Write Cycle



Read Cycle

Table 0-4: Serial Interface Timing Characteristics (4-wire SPI)

(V_{DD} - V_{SS} = 1.65V~3.5V, T_A = 25℃)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	100	-	-	ns
t_{AS}	Address Setup Time	15	-	-	ns
t_{AH}	Address Hold Time	15	-	-	ns
t_{CSS}	Chip Select Setup Time	20	-	-	ns
t_{CSH}	Chip Select Hold Time	10	-	-	ns
t_{DSW}	Write Data Setup Time	15	-	-	ns
t_{DHW}	Write Data Hold Time	15	-	-	ns
t_{CLKL}	Clock Low Time	20	-	-	ns
t_{CLKH}	Clock High Time	20	-	-	ns
t_R	Rise Time	-	-	40	ns
t_F	Fall Time	-	-	40	ns

Figure 0-3: Serial interface characteristics (4-wire SPI)

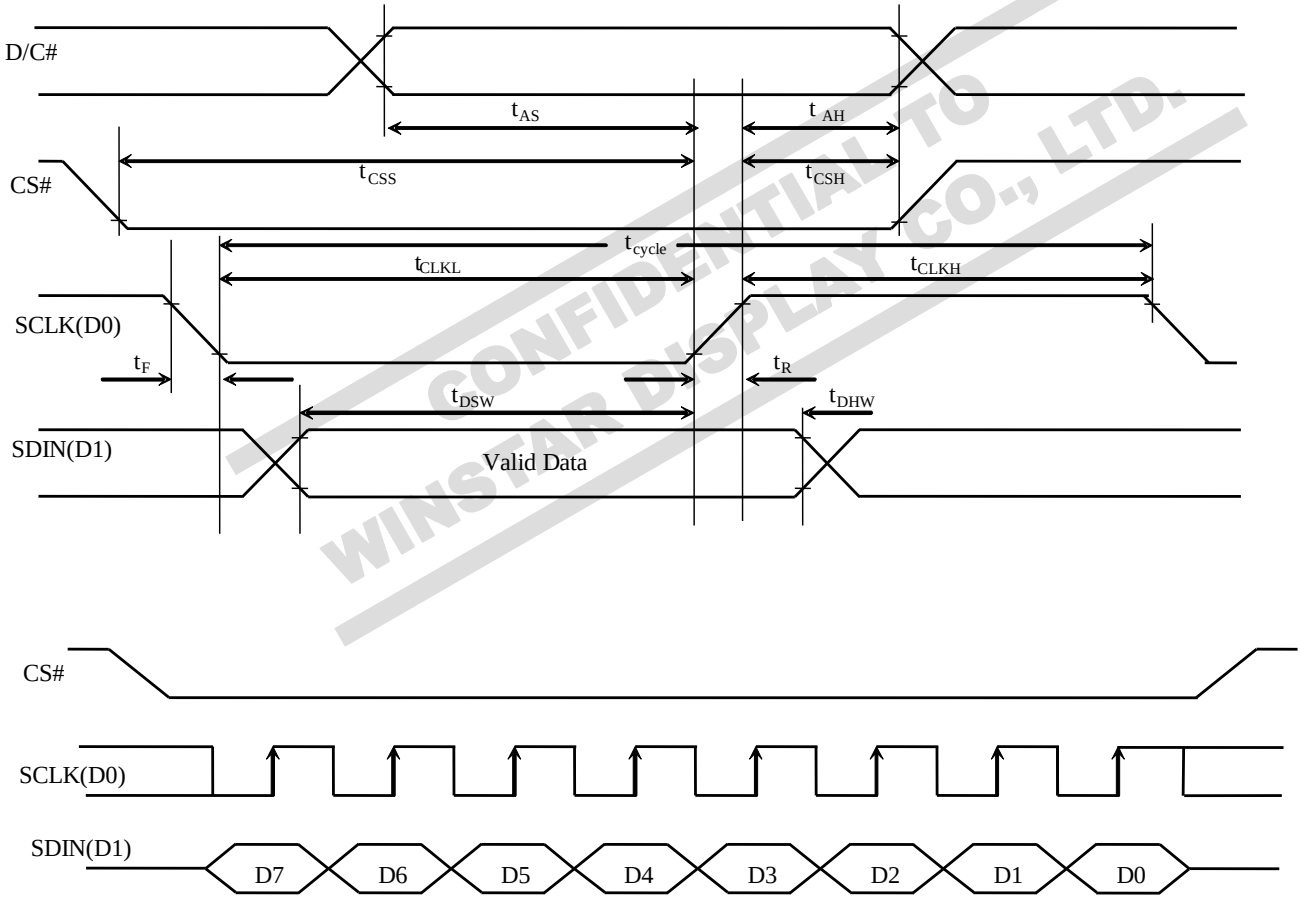


Table 0-5: Serial Interface Timing Characteristics (3-wire SPI)

(V_{DD} - V_{SS} = 1.65V~3.5V, T_A = 25℃)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	100	-	-	ns
t_{CSS}	Chip Select Setup Time	20	-	-	ns
t_{CSH}	Chip Select Hold Time	10	-	-	ns
t_{DSW}	Write Data Setup Time	15	-	-	ns
t_{DHW}	Write Data Hold Time	15	-	-	ns
t_{CLKL}	Clock Low Time	20	-	-	ns
t_{CLKH}	Clock High Time	20	-	-	ns
t_R	Rise Time	-	-	40	ns
t_F	Fall Time	-	-	40	ns

Figure 0-4: Serial interface characteristics (3-wire SPI)

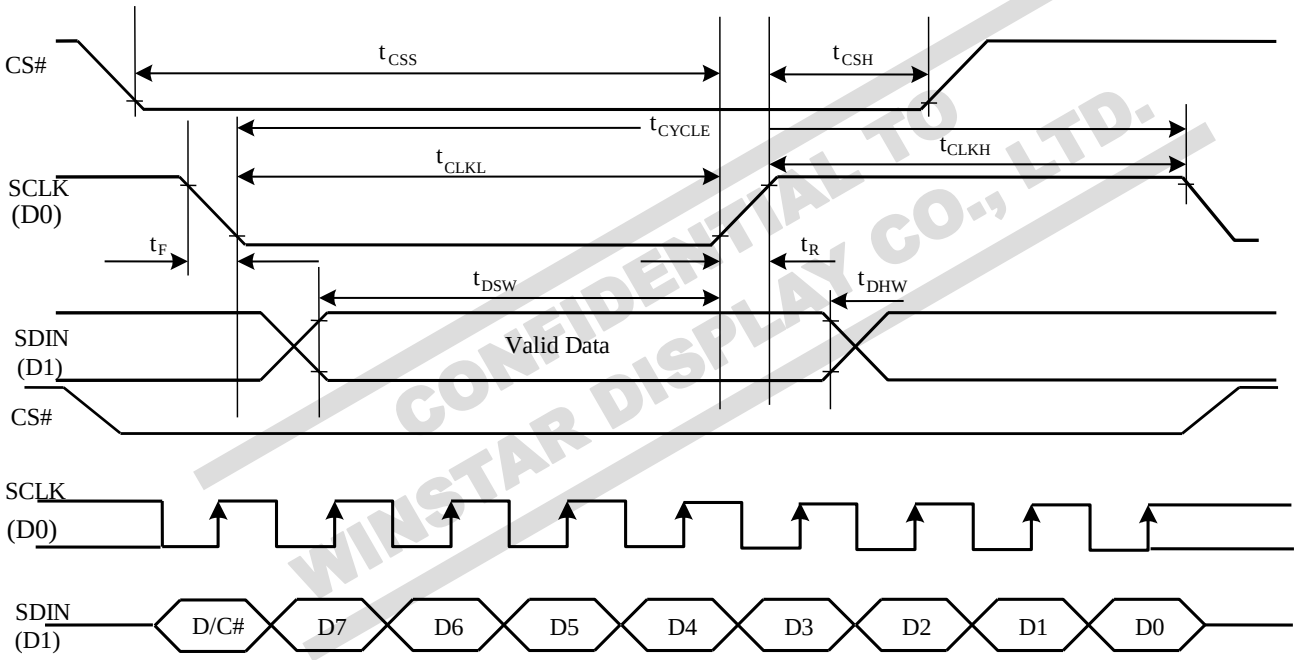
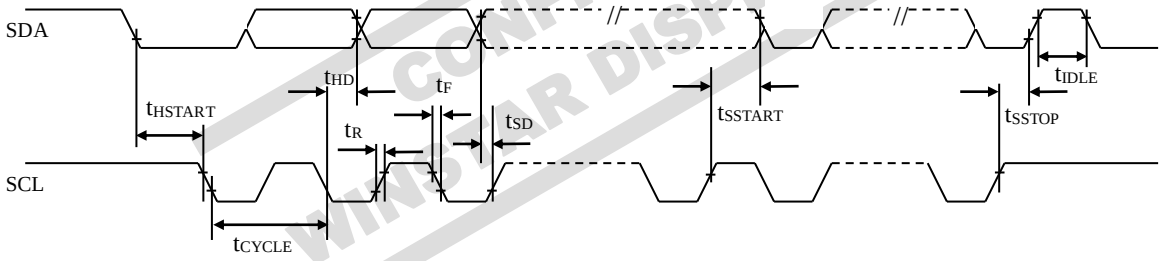


Table 0-6: I2C Interface Timing Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	2.5	-	-	us
t_{HSTART}	Start condition Hold Time	0.6	-	-	us
t_{HD}	Data Hold Time (for "SDA_{OUT}" pin)	0	-	-	ns
	Data Hold Time (for "SDA_{IN}" pin)	300	-	-	ns
t_{SD}	Data Setup Time	100	-	-	ns
t_{SSTART}	Start condition Setup Time (Only relevant for a repeated Start condition)	0.6	-	-	us
t_{SSTOP}	Stop condition Setup Time	0.6	-	-	us
t_R	Rise Time for data and clock pin	-	-	300	ns
t_F	Fall Time for data and clock pin	-	-	300	ns
t_{IDLE}	Idle Time before a new transmission can start	1.3	-	-	us

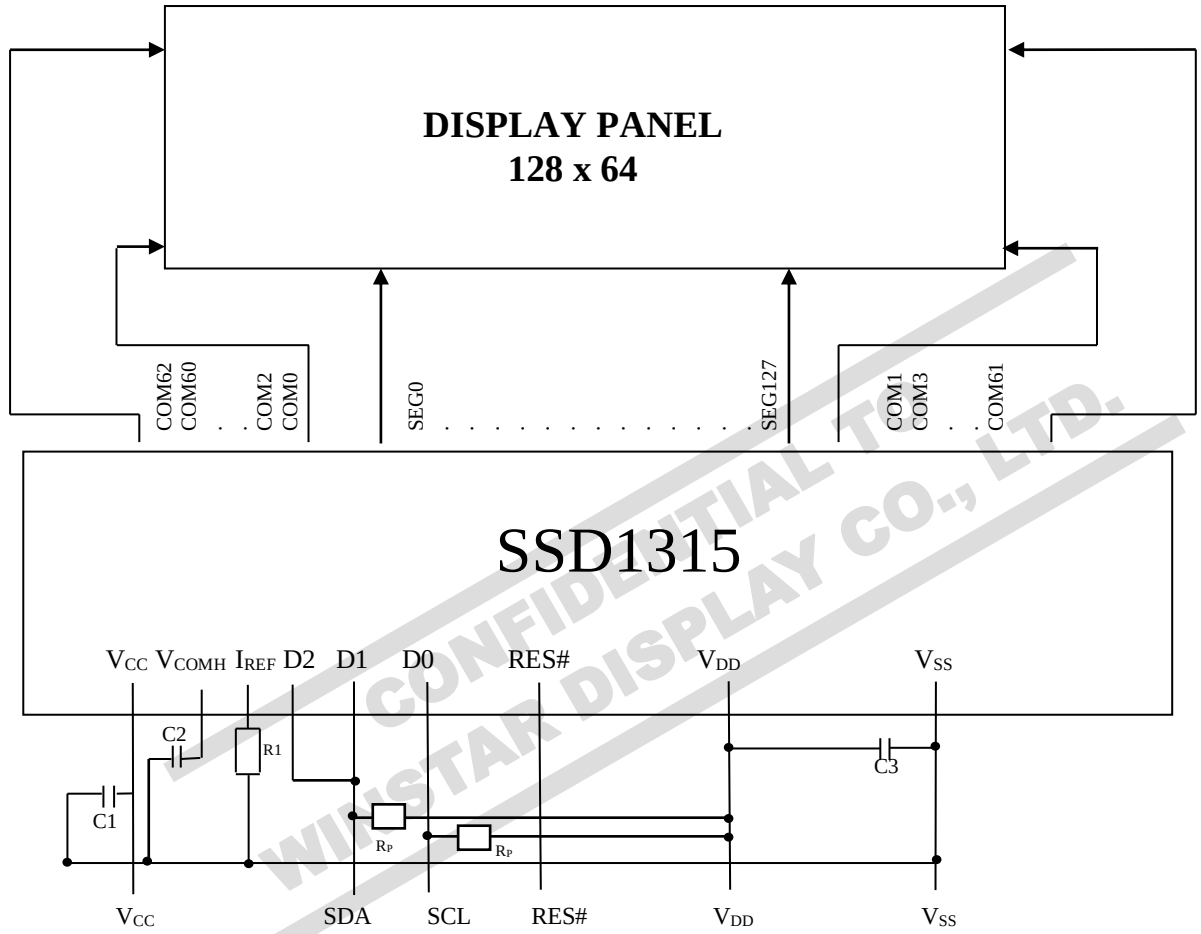
Figure 0-5 I2C interface Timing characteristics



9 APPLICATION EXAMPLE

Figure 9-1: Application Example of SSD1315 with External V_{CC} and I^2C interface

The configuration for I^2C interface mode is shown in the following diagram:
(V_{DD}= 2.8V, V_{CC} =12V, I_{REF} =30uA)



Pin connected to MCU interface: RES#, SDA, SCL
Pin internally connected to V_{SS}: BS0, BS2, CL, D[7:3], E, R/W#, CS#, D/C#, BGGND, LS
Pin internally connected to V_{DD}: BS1, CLS
$V_{BAT,}$ C1P, C1N, C2P, C2N, FR should be left open.

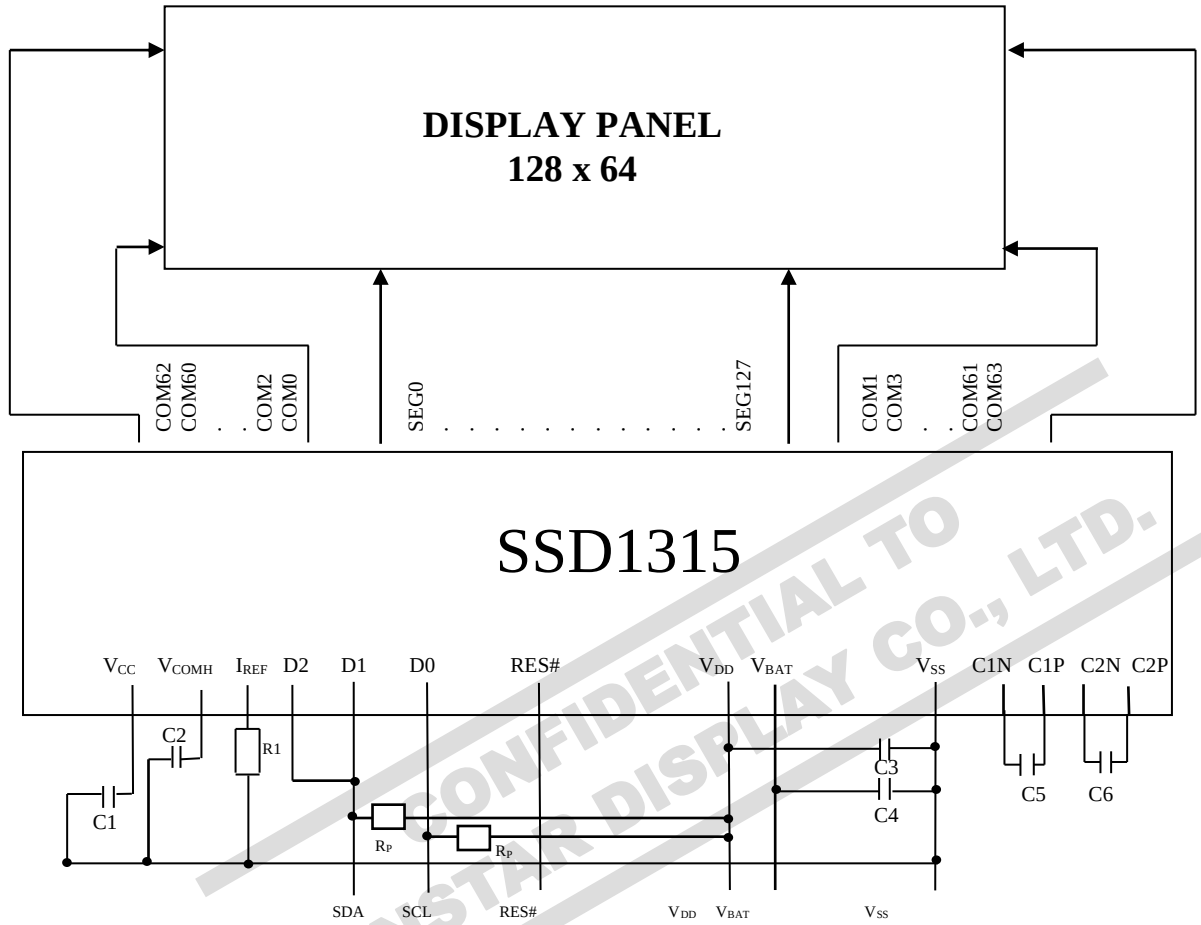
C1, C2: 2.2uF (1)
C3: 1.0uF (1)
R_P : Pull up resistor

Voltage at I_{REF} = V_{CC} – 3V. For V_{CC} = 12V, I_{REF} = 30uA:
R1 = (Voltage at I_{REF} - V_{SS}) / I_{REF}
= (12-3) / 30uA
= 300KΩ

Note
(1) The capacitor value is recommended value. Select appropriate value against module application.
(2) V_{LSS} of IC pad no. 29-30 are recommended to be connected to the V_{LSS} of pad no. 77-78 to form a larger area of GND.
(3) V_{LSS} and V_{SS} are not recommended to be connected on the ITO routing, but connected together in the PCB level at one common ground point for better grounding and noise insulation.

Figure 9-2: Application Example of SSD1315 with Internal Charge Pump and I²C interface

The configuration for I²C interface mode is shown in the following diagram:
(V_{DD}= 1.65V ~ 3.5V, V_{BAT}=3.0V~4.5V, I_{REF}=30uA)



Pin connected to MCU interface: RES#, D[2:0]
Pin internally connected to V_{SS}: BS0, BS2, CL, D[7:3], E, R/W#, CS#, D/C#, BGGND, LS
Pin internally connected to V_{DD}: BS1, CLS
FR should be left open.

C1, C2: 2.2uF (1)
C3, C4 : 1.0uF (1)
C5, C6: 1.0uF/10V (1)
R_P : Pull up resistor

Voltage at I_{REF} = V_{CC} – 3V. For V_{CC} = 7.5V, I_{REF} = 30uA:
R1 = (Voltage at I_{REF} - V_{SS}) / I_{REF}
= (7.5-3) / 30u
=150KΩ

Note
(1) The capacitor value is recommended value. Select appropriate value against module application.
(2) V_{LSS} of IC pad no. 29-30 are recommended to be connected to the V_{LSS} of pad no. 77-78 to form a larger area of GND.
(3) V_{LSS} and V_{SS} are not recommended to be connected on the ITO routing, but connected together in the PCB level at one common ground point for better grounding and noise insulation.

The product(s) listed in this datasheet comply with Directive 2011/65/EU of the European Parliament and of the council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment and People's Republic of China Electronic Industry Standard SJ/T 11363-2006 "Requirements for concentration limits for certain hazardous substances in electronic information products (电子信息产品中有毒有害物质的限量要求)". Hazardous Substances test report is available upon request.

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